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Triga Mark III reactor operating power and neutron flux study by Nuclear Track Methodology

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Abstract

The operating power of a TRIGA Mark III reactor was studied using Nuclear Track Methodology (NTM). The facility has a Highly Enriched Uranium core that provides a neutron flux of around 2 x 10^{12} n cm^{-2} s^{-1} in the TO-2 irradiation channel. The detectors consisted of a Landauer® CR-39 (allyl diglycol polycarbonate) chip covered with a 3 mm Plexiglas® converter. After irradiation, the detectors were chemically etched in a 6.25M-KOH solution at 60±1°C for 6h. Track density was determined by a custom-made Digital Image Analysis System. The results show a direct proportionality between reactor power and average nuclear track density for powers in the range 0.1-7 kW. Data reproducibility and relatively low uncertainty (±3%) were achieved. NTM is a simple, fast and reliable technique that can serve as a complementary procedure to measure reactor operating power. It offers the possibility of calibrating the neutron flux density in any low power reactor.
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Keywords: nuclear tracks; reactor power; CR-39; polycarbonate

1. Introduction

Nuclear Research Reactors have been an important and interesting instrument for the development of neutron applications ranging from basic science to high technology in many different fields, including biology, physics,

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materials science, astronautic engineering and earth sciences, and ranging from basic science to high technology. One of the most important parameters of the neutron flux for a given output power of the research reactor. This parameter may be determined by any of several techniques, all of them necessarily indirect. One technique, the use of activation foils, requires a costly nuclear spectroscopy system. An alternative method is to follow a simpler approach employing passive detectors (Castillo et al., 2013; Pálfalvi et al., 2001). Nuclear Track Methodology (NTM) (Espinosa, 1994) has demonstrated its usefulness for neutron detection and dosimetry; it is one of the most frequently used alternatives based on the neutron-proton interaction (Hermsdorf et al., 2011). Therefore, the absolute value of the neutron flux or the variation in reactor power can be measured by advantageously employing Nuclear Track Detectors (NTD). In this paper we investigate the relation between the operating power and the neutron flux of a TRIGA Mark III reactor using NTD. The results of this study are a contribution to nuclear science in the field of fission neutron density and reactor power response employing the relatively simple, reliable and fast NTM technique.

2. Results

The value of the reactor power is given by the operator using the reactor calibration. The experimental procedure used to measure the track densities was outlined in the abstract. Average track density is plotted against output power for the detectors without Cd filter (A) and the cadmium-covered detectors (B) in Figure 1. The detectors show a closely proportional response from 100 to 7000 W reactor power; the linearity of the response of the cadmium-covered detectors cuts off at 5000 W. This cut-off may be explained by the presence of the cadmium filter, it is observed experimentally basically because the neutrons spectrum produced by the TRIGA Mark III and his specific uranium bars distribution.

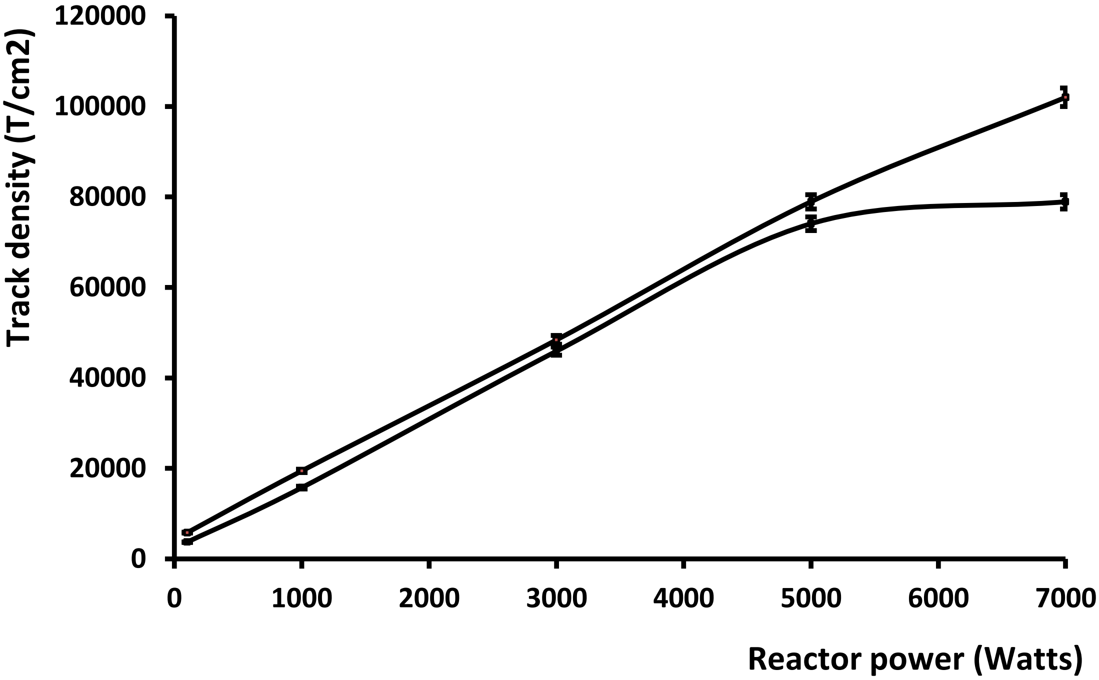

Fig. 1. Track density as a function of operating power for detectors without Cd filter (A) and cadmium-covered detectors (B).

3. Conclusions

CR-39 track detectors have been used to determine the neutron flux of a TRIGA Mark III reactor as a function of reactor operating power. The neutron flux was found to be closely proportional to reactor power except for an apparent flux drop-off as measured with Cd-covered detectors at the highest reactor power used of 7 kW. Such track technique offers a simple low-cost alternative method for measuring and verifying the neutron flux in uncharacterized reactor channels.

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References

Castillo, F., Espinosa, G., Golzarri, J.I., Osorio, D., Rangel, J., Reyes, P.G., Herrera, J.J.E., (2013). Fast neutron dosimetry using CR-39 track detectors with polyethylene as radiator. Radiat. Meas. 50, 71-73.

Espinosa, G., (1994). Trazas Nucleares en Sólidos. UNAM, Mexico, ISBN 968-36-4219-5.

Hermsdorf, D. (2011). Physics aspects of light particle registration in PADC detectors of type CR-39. Radiat. Meas., 46, 396-404.

Pálfalvi J.K., Sajó-Bohus, L., Balaskó M., Balásházy I., (2001). Neutron field mapping and dosimetry by CR-39 for radiography and other applications. Rad. Meas., 34 (1-6) 471- 475.